UNIFIED FACILITIES GUIDE SPECIFICATIONS

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DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13110N

CATHODIC PROTECTION BY GALVANIC ANODES

09/99

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USACE / NAVFAC / AFCESA **UFGS-L-13110N (MARCH 2001)**

Preparing Activity: LANTNAVFACENGCOM

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 13110N

CATHODIC PROTECTION BY GALVANIC ANODES
09/99

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NOTE: This guide specification covers the requirements for underground piping and buried or submerged structure cathodic protection systems using galvanic anodes systems. The requirements for the cathodic protection systems should be determined by a corrosion engineer following the criteria, design, and installation recommendations included in the National Association of Corrosion Engineers (NACE) Standard RP0169 Control of External Corrosion on Underground or Submerged Metallic Piping Systems and others listed in the specification.

NOTE: Suggestions for improvement of this specification will be welcomed using the Navy "Change Request Forms" subdirectory located in SPECSINTACT in Jobs or Masters under "Forms/Documents" directory or DD Form 1426. Suggestions should be forwarded to:

Commander
Naval Facilities Engineering Command
Engineering Innovation and Criteria Office, Code EICO
1510 Gilbert Street
Norfolk, VA 23511-2699

Email: LantDiv@efdlant.navfac.navy.mil

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
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NOTE: The following NAVFAC Guide Specification sections provide structures requiring cathodic protection. Coordinate with these sections for the galvanic anode system design, pipeline/tank dielectric isolation, cathodic protection system installation and testing requirements.

--Section 02551, "Natural Gas Distribution"
--Section 02553, "Exterior Underground Steam Distribution"
--Section 02555, "Exterior Fuel Distribution"
--Section 13205, "Steel Tanks With Fixed Roofs"
--Section 13216, "Underground Petroleum Tanks"
--Section 15192, "Fuel Oil Piping"
--Section 15193, "Gasoline/Diesel Dispensing Systems"
--Section 15194, "Aviation Fuel Distribution and Dispensing"
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NOTE: The following information should be on the drawings:

1. Location of all underground pipes and structures.

2. Locations of all anodes and test stations.

3. Locations of all flanges and unions.

4. Installation details for anodes and test stations.

5. Location of equipment.

6. Single-line diagrams elevations, limiting dimensions, and equipment ratings which are not covered in the specification.

7. Remote indicating or control requirements.
****

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.2.1	(1981; R 1992) Square and Hex Bolts and Screws Inch Series
ANSI C2	(1997) National Electrical Safety Code
ANSI C119.1	(1986) Electrical Connectors - Sealed Insulated Underground Conductor Systems Rated 600 Volts

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(1989) Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI/ASME B1.20.1	(1983; R 1992) Pipe Threads, General Purpose (Inch)
ASME/ANSI B16.5	(1996) Pipe Flanges and Flanged Fittings
ASME B16.21	(1992) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.25	(1992) Buttwelding Ends
ASME/ANSI B16.39	(1986; R 1994) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME/ANSI B18.2.2	(1987; R 1993) Square and Hex Nuts (Inch Series)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 194/A 194M	(1996) Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
ASTM A 307	(1994) Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM B 3	(1995) Soft or Annealed Copper Wire
ASTM B 8	(1995) Concentric-Lay-Strandedd Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B 418	(1995; Rev. A) Cast and Wrought Galvanic Zinc Anodes
ASTM B 843	(1993) Magnesium Alloy Anodes for Cathodic Protection

ASTM C 94	(1996) Ready-Mixed Concrete
ASTM D 2028	(1976; R 1992) Cutback Asphalt (Rapid-Curing Type)
ASTM D 3381	(1992) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM F 1182	(1990; R 1994) Anodes, Sacrificial Zinc Alloy

MILITARY SPECIFICATIONS (MIL)

MIL-I-1361	(Rev. C) Instrument Auxiliaries, Electrical Measuring: Shunts, Resistors, and Transformers

NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE)

NACE RP0169	(1996) Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE RP0285	(1995) Corrosion Control of Underground Storage Tanks Systems by Cathodic Protection

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993) Industrial Control and Systems Enclosures
NEMA RN 1	(1989) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(1990) Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

UNDERWRITERS LABORATORIES INC. (UL)

UL 6	(1997) Rigid Metal Conduit
UL 44	(1997; Bul. 1997 R 1998) Thermostat-Insulated Wires and Cables
UL 83	(1998) Thermoplastic-Insulated Wires and Cables
UL 486A	(1997; R 1998) Wire Connectors and Soldering Lugs for Use With Copper Conductors
UL 510	(1994; R 1998) Chloride, Polyethylene, and Rubber Insulating Tape

UL 514A	(1996; R 1998) Metallic Outlet Boxes
UL 514B	(1997; R 1998) Fittings for Conduit and Outlet Boxes

1.2 RELATED REQUIREMENTS

Section 16050N, "Basic Electrical Materials and Methods," applies to this section except as modified herein.

1.3 SUBMITTALS

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NOTE: Where a "G" in submittal tags follows a submittal item, it indicates Government approval for that item. Add "G" in submittal tags following any added or existing submittal items deemed sufficiently critical, complex, or aesthetically significant to merit approval by the Government. Submittal items not designated with a "G" will be approved by the QC organization.

****

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Anode junction boxes, bonding boxes, and test stations; G

Insulating flange sets; G

Joint bonds; G

SD-03 Product Data

Anodes; G

Anode junction boxes, bonding boxes, and test stations; G

Insulating flange sets; G

Dielectric unions; G

Cable; G

Casings, insulation, and seals; G

Shunt resistors; G

Wires; G

SD-06 Test Reports

Initial field testing; G

Warranty period testing; G

Final field testing; G

Initial test report; G

SD-07 Certificates

Qualifications of corrosion engineer; G

SD-10 Operation and Maintenance Data

Cathodic Protection System, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01781N, "Operation and Maintenance Data."

1.4 SERVICES AND QUALIFICATIONS OF CORROSION ENGINEER

The Contractor shall obtain the services of a corrosion engineer to supervise, inspect and test the installation of the cathodic protection system(s). The Contractor's corrosion engineer refers to a person, who, by reason of their knowledge of the physical sciences, the principles of engineering and mathematics as acquired by a professional education and related practical experience, is qualified to engage in the practice of corrosion control of underground or submerged structures. Such a person will be a registered professional engineer with certification of licensing that includes education and experience in cathodic protection of buried or submerged metal structures, or a person accredited or certified by the National Association of Corrosion Engineers at the level of corrosion specialist or cathodic protection specialist. Such a person shall have not less than 5 years experience in the cathodic protection of shore facilities.

1.5 GOVERNMENT CORROSION ENGINEER

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NOTE: The LANTDIV corrosion engineer shall provide Government corrosion engineering functions for all LANTDIV areas including those installations in EFA CHES, EFA MED, and OICC NAVHOSP.

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The geographic Engineering Field Division's corrosion [program manager] [engineer] or their designated representative will provide all functions relative to the Government corrosion enginer. The Government corrosion engineer shall be LANTNAVFACENGCOM, Code 1614C, 1510 Gilbert Street, Norfolk, VA 23511-2699. The Government corrosion engineer shall provide technical assistance to the Contracting Officer and shall provide Government field testing of the cathodic protection systems as indicated herein and in association with the Contracting Officer.

PART 2 PRODUCTS

2.1 ANODES

[2.1.1 Magnesium

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NOTE: The chemical composition listed is for high potential anodes. Should standard magnesium anodes be considered suitable, consult MIL-HDBK-1004/10,

"Electrical Engineering Cathodic Protection" for criteria concerning their use. Specify chemical composition which will provide adequate and economical service.

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[ASTM B 843] Chemical composition as follows:

Aluminum	[0.05] [_____] percent maximum
Manganese	[0.05-1.3] [_____] percent
Zinc	[-0-] [_____] percent [maximum]
Silicon	[-0-] [_____] percent [maximum]
Copper	[0.02] [_____] percent maximum
Nickel	[0.001] [_____] percent maximum
Iron	[0.03] [_____] percent maximum
Other Impurities	0.05 percent each, 0.3 percent maximum total
Magnesium	Remainder

a. Bare anode weight: [4.1] [7.72] [14.53] [_____] kg [[9] [17] [32] [_____] pounds] [not including core].

b. Anodes [with galvanized steel core [tape] [rod]] and anode wire, silver soldered to the core. Insulate soldered connection and recess end of the anode to a 600 volts rating with [asphaltic] [epoxy] and cover the connection with heat shrinkable tubing. Insulating material shall extend over the connection and cover the lead wire insulation by not less than 15 mm 1/2 inch.

][2.1.2 [Cast] [Wrought] Zinc

[ASTM B 418, Type [I] [II].] [ASTM F 1182.] Bare anode weight: [2.2] [13.62] [_____] kg [5] [30] [_____] pounds [not including core].

][2.1.3 Aluminum

Chemical composition as follows:

Zinc	[4.5] [_____] percent maximum
Indium	[0.02] [_____] percent maximum
[Cadmium	[0.01] [_____] percent maximum]
Aluminum remainder	
Anode weight [_____] kg [_____] pounds not including core.	

]2.1.4 Anode Wires and Core

2.1.4.1 Anode Lead Wires

UL 83. Type [TW] [THWN] [HMWPE] [THHN], [UL 44, Type [RHW] [RHH]], [solid] [stranded] copper conductors, not less than [No. 12] [_____] AWG, [3050] [6100] [_____] mm [10] [20] [_____] feet long, [and extend to the accompanying junction box without splicing]. Anode lead wire shall be factory installed. [Silver solder the lead wire to the anode core, and seal the soldered connection and recessed end of the anode with a dielectric sealing compound.] [Silver solder the lead wire to the protruding anode core, and completely seal the soldered connection with a dielectric material.] Dielectric material shall extend past the connection and cover the lead wire insulation by not less than 15 mm 1/2 inch.

2.1.4.2 Anode Core

Iron [galvanized steel] rod [pipe] [strap] [_____], [3] [6.35] [12.7] mm diameter [_____] by [_____] [1/8] [1/4] [1/2] inch diameter [_____] by [_____].

2.1.5 Anode Backfill

Chemical composition as follows:

Hydrated gypsum	-	75 percent
Bentonite clay	-	20 percent
Sodium sulfate	-	5 percent

Provide granular backfill with 100 percent passing through a 150 micrometers 100 mesh screen. Provide prepackaged anode in a cloth bag containing the anode and backfill. Center the anode in the firmly packed backfill using spacers. Overall dimensions of the bagged [7.72] [14.53] [_____] kg [17] [32] [_____] pound anode shall be [165 mm by 432 mm] [203 by 535 mm] [_____ mm by _____ mm] [6.5 inches by 17 inches] [8 inches by 21 inches] [_____ inches by _____ inches] with a total minimum weight of [20.4] [33.6] [_____] kg [45] [74] [_____] poundsnominal.

2.2 ANODE JUNCTION BOXES, BONDING BOXES, AND TEST STATIONS

2.2.1 Flush Mounted Type

NEMA ICS 6. Non-metallic enclosure with terminal board, [five] [eight] [_____] terminal posts and lockable cover plate. Non-metallic enclosures shall be high impact strength molded plastic and mounted on a 100 mm 4 inch PVC conduit, 500 mm 18 inch length, minimum. The unit shall be of standard design manufactured for use as a cathodic protection test station, complete with cover, terminal board, shunts, and brass or 17.7 stainless steel hardware. The terminal board shall be removable for easy access to wires. The cover shall be [plastic] [or] [cast iron with a cast in legend "CP TEST"]. [Provide traffic rated box capable of withstanding [H-20] [_____] traffic loads.]

2.2.2 Post Top Mounted Type

NEMA ICS 6. Non-metallic or metallic enclosure with terminal board, [five] [eight] [_____] terminal posts and lockable cover. Non-metallic enclosures shall be high impact strength molded plastic. Metallic enclosures shall be cast metal, hub type, unless otherwise indicated. The unit shall be of standard design manufactured for use as a cathodic protection test station complete with cover, terminal board, shunts, and brass or 17.7 stainless steel hardware. The cover shall be removable for easy excess to terminal board and wires. Non-metallic test stations shall be mounted atop a 1830 mm 6 foot long polyethylene conduit with anchor. Metallic test stations shall be mounted atop galvanized steel conduit with anchor.

2.2.3 Wall/Post Mounted Type

NEMA ICS 6. NEMA Type [3R] [4X] [_____] enclosure with [clamped cover] [stainless steel hinges and [clamp] [latched] cover] [and padlocked hasp]. Enclosure shall be of [galvanized steel] [painted steel] [aluminum] [fiberglass] [non-metallic] construction with terminal board and labeled with nameplate. Provide nameplate in accordance with Section 16050N, "General Electrical Materials and Methods." Enclosure mounting posts shall be [steel pipe, schedule [40] [80] [_____]], [steel channel], [wood post,

full length pressure treated with pentachlorophenol] [as indicated]. Mount enclosure [1066 mm 42 inches above finished grade] [as indicated].

2.2.3.1 Terminal Boards

Provide terminal boards for anode junction boxes, bonding boxes, and test stations made of phenolic plastic [3] [6] [_____] mm [1/8] [1/4] [_____] inch thick with dimensions as indicated. Insulated terminal boards shall have the required number of terminals (one terminal required for each conductor). Install solderless copper lugs, copper buss bars, shunts, and variable resistors on the terminal board as indicated. Test station terminal connections shall be permanently tagged to identify each termination of conductors (e.g., identify the conductors connected to the protected structure, anodes, and reference electrodes). Conductors shall be permanently identified by means of plastic or metal tags, or plastic sleeves to indicate termination.

2.2.4 Color Coding of Conductors

Each conductor shall be color coded as follows:

Anode lead wire - black
Structure lead wire - white
Reference electrode lead wire - red

2.2.5 Shunt Resistors

[MIL-I-1361.] [0.01] [_____] ohm, [6] [_____] ampere, accuracy plus or minus one percent, manganin wire type.

2.2.6 [Pavement Inserts

Pavement inserts shall be a non-metallic flush type test station without terminal board and shall allow a copper-copper sulfate reference electrode to contact the soil beneath the pavement surfaces. Minimum interior diameter of conduit shall be 50 mm 2 inches. [Provide traffic rated box capable of withstanding [H-20] [_____] traffic loads.]]

2.3 PERMANENT REFERENCE ELECTRODES

Permanent reference electrodes shall be [copper-copper sulfate] [silver-silver chloride] [zinc] specifically manufactured for [underground] [marine] use, [32] [_____] mm [1 1/4] [_____] inch diameter, by [255] [_____] mm [10] [_____] inches long, [plastic [_____] tube with an ion trap to minimize contamination of the cell.] [The cell shall be prepackaged by the manufacturer with a backfill material as recommended by the manufacturer.] Provide cells with No. [10] [12] [_____] AWG, [RHW] [THHN] [_____] cable of sufficient length to extend to the [test station] [junction box] without splicing. Reference electrodes shall have 15 year life, minimum and an accuracy of plus or minus 5 millivolts.

2.4 CABLE

[UL 83, Type [TW] [THWN] [THHN] and [HMWPE]], [UL 44, Type RHW], [solid] [stranded] copper conductor, color coded and sized (based on AWG). Copper wires shall conform to ASTM B 3 and ASTM B 8. Lead wires terminating at a junction box or test station shall have a cable identification tag. [Do not use bare copper wire for joint continuity bonds.]

2.5 CABLE IDENTIFICATION TAGS

[Laminated plastic material with black letters on a yellow background] [Brass] [Stainless steel] [material with engraved letters]. Print letters and numbers a minimum of 5 mm 3/16 inch in size. Provide identifier legend [_____].

2.6 WIRE CONNECTORS

UL 486A. [_____] [Solderless copper lugs].

2.7 UNDERGROUND SPLICES

****
NOTE: Delete this paragraph if underground splices are not allowed from anodes to test stations.
****

Provide splices with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

a. Provide cast-type splice insulation by means of molded casting process employing a thermosetting epoxy resin insulating material applied by a gravity poured method or by a pressure injected method. Provide component materials of the resin insulation in a packaged form ready for convenient mixing without removing from the package.

(1) Gravity poured method shall employ materials and equipment contained in an approved commercial splicing kit which includes a mold suitable for the cables to be spliced. When the mold is in place around the joined conductors, prepare the resin mix and pour into the mold.

b. Provide [heavy wall] heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which shall be applied by a clean burning propane gas torch.

2.8 CONDUIT

[UL 6, rigid galvanized steel], [Outlet boxes: UL 514A and fittings UL 514B, threaded hubs]. [Metallic conduit and fittings to be PVC coated in accordance with NEMA RN 1, Type A40], [NEMA TC 2, Type EPC-40-PVC].

2.9 TAPE

2.9.1 Buried Warning and Identification Tape

Provide detectable aluminum foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried cable and conduit. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, [75] mm [3] [_____] inches minimum width, [[yellow] [_____] in color] [color coded for the utility involved] with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be "CAUTION BURIED [ANODE] CABLE BELOW" or similar. Use permanent code and letter coloring unaffected by moisture and other

substances contained in trench backfill material.

2.9.2 Insulating Tape

UL 510.

2.10 INSULATING FLANGE SETS

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NOTE: Coordinate the requirements for insulating flanges with the appropriate section(s) in Division 2, SITEWORK and/or Division 15, MECHANICAL, responsible for the installation of pipelines or storage tanks under cathodic protection.
****

Provide full-faced gaskets, insulating sleeves and washers, and steel washers. Provide insulating flange sets rated for operation at the rated pressure and temperature.

2.10.1 Gaskets

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NOTE: Do not use asbestos materials.
****

ASME B16.21. [Neoprene faced phenolic] [Laminated phenolic] material for operation at [_____] KPa, [232] [_____] degrees C [_____] psi, [450] [_____] degrees F.

2.10.2 Insulating Washers and Sleeves

Two sets [3 mm1/8 inch laminated phenolic] [_____] for operation at [232] [_____] degrees C [450] [_____] degrees F. Insulating washers shall fit within the bolt facing on the flange over the outside of the fabric reinforced phenolic sleeve.

2.10.3 Washers

Steel, cadmium plated, to fit within the bolt facing on the flange.

2.11 STEEL FLANGES AND BOLTING

2.11.1 Steel Flanges

ASME/ANSI B16.5 [668 N] [1335 N] [150 lb.] [300 lb.].

2.11.2 Bolting

ASTM A 307, Grade B for bolts; ASTM A 194/A 194M, Grade 2 for nuts. Dimensions: ANSI B18.2.1 for bolts, ASME/ANSI B18.2.2 for nuts. Threads: ASME B1.1, Class 2A fit for bolts, Class 2B fit for nuts. Bolts shall extend completely through the nuts and may have reduced shanks of a diameter not less than the diameter at the roof of threads.

2.12 DIELECTRIC UNIONS

****
NOTE: Coordinate the requirements for dielectric

unions with the appropriate section(s) in Division 2, SITEWORK and/or Division 15, MECHANICAL, responsible for the installation of pipelines or storage tanks under cathodic protection.

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ASME/ANSI B16.39, Class [1] [2] for dimensional, strength, and pressure requirements. Insulation barrier shall limit galvanic current to one percent of the short-circuit current in a corresponding metallic joint. Provide insulating material impervious to [water] [oil] [gas].

2.13 EXOTHERMIC WELD KITS

Exothermic weld kits specifically designed by the manufacturer for welding the types of materials and shapes provided.

2.14 ELECTRICALLY INSULATING COATINGS

[Heat-shrinkable tape] [Conformable water tight sealant having dielectric strength not less than 15 kV for a 3 mm 1/8 inch thick layer].

2.15 CASING INSULATORS AND SEALS

Casing insulators shall have a minimum [305] [_____] mm [12] [_____] inch band width, [constructed of heat fused plastic coated steel] [_____] and multi-segmented to attach firmly around the pipe. Casing end seals shall be S-shaped rubber seals with stainless steel straps.

PART 3 EXECUTION

3.1 INSTALLATION

NFPA 70, ANSI C2.

3.1.1 Anodes and Lead Wires

Provide [each] anode and lead wires as follows:

a. Excavate hole to a minimum 75 mm 3 inches larger than the packaged anode diameter, [_____] mm [_____] feet deep.

b. Excavate lead wire trench to [610] [_____] mm [24] [_____] inches deep, [_____] mm [_____] inches wide.

c. Do not lift or support anode by the lead wire. Where applicable, remove manufacturer's plastic wrap/bag from the anode. Exercise care to preclude damaging the cloth bag and the lead wire insulation.

d. Center the packaged anode in the hole with native soil in layers not exceeding 150 millimeters 6 inches. Hand tamp each layer to remove voids taking care not to strike the anode lead wire. When the backfill is 150 millimeters 6 inchesabove the top of the anode, pour not less than 10 gallons of water into the hole to saturate the anode backfill and surrounding soil. Anodes shall not be backfilled prior to inspection and approval by the Contracting Officer.

e. Cover the lead wire trench bottom with a 75 mm 3 inch layer of

sand or stone free earth. Center wire on the backfill layer, do not stretch or kink the conductor. Place backfill over wire in layers not exceeding 150 mm 6 inches deep, compact each layer thoroughly. Do not place tree roots, wood scrap, vegetable matter, and refuse in backfill. Place cable warning tape within [450] [_____] mm [18] [_____] inches of finished grade, above cable and conduit.

f. Connect anode lead wire(s) [to the test station terminal board(s)] [directly to the protected structure(s) by use of exothermic weld kit(s)]. Clean the structure surface by scraping, filing, or wire brushing to produce a clean, bright surface. [Weld connections using exothermic kit(s) in accordance with the kit manufacturer's instructions.] Check and verify adherence of the bond to the substrate for mechanical integrity by striking the weld with a 908 gram 2 pound hammer. Cover connections with an electrically insulating coating [which is compatible with the existing coating on the structure]. Allow sufficient slack in the lead wire to compensate for movement during backfilling operation.

g. Connect structure leads to structure by use of a exothermic weld kit(s). Clean the structure surface by scraping, filing, or wire brushing to produce a clean, bright surface. [Weld connections using exothermic kit(s) in accordance with the kit manufacturer's instructions.] Check and verify adherence of the bond to the substrate for mechanical integrity by striking the weld with a 908 gram 2 pound hammer. Cover connections with an electrically insulating coating [which is compatible with the existing coating on the structure.] Connect structure lead wires to the test station terminal board(s).

3.1.2 Anode Junction Boxes

Provide junction boxes and mark wire terminating in boxes.

3.1.3 Bonding Boxes

Provide structure bonding boxes where protected pipe crosses other metal pipes which are unprotected or on other cathodic protection systems.

3.1.4 Test Stations

Provide test stations as follows:

a. At [305] [_____] meters [1000] [_____] foot intervals.

b. At all insulating joints.

c. At both ends of casings.

d. Where the pipe crosses any other metal pipes.

e. Where the pipe connects to an existing piping system.

f. Where the pipe connects to a dissimilar metal pipe.

Do not fill the bottom of the test station with concrete unless otherwise specified.

3.1.4.1 Flush Mounted Type

Flush mount type test stations, bonding boxes, and anode junction boxes shall be centered in an 460 by 460 by 305 mm 18 by 18 by 12 inch concrete block. Concrete shall conform to the requirements indicated herein.

3.1.5 Insulating Flange Sets

Provide insulating flange sets as indicated. [Cut piping and provide flanges into place without springing or forcing. Weld in accordance with ASME B16.25.] [Cover flanges with an electrically insulating coating.]

3.1.6 Dielectric Unions

Provide insulating unions as indicated. [Cut pipe ends square, remove fins and burrs, cut taper pipe threads in accordance with ANSI/ASME B1.20.1.] Apply joint compound or thread tape to male threads only. Work piping into place without springing or forcing. Backing off to permit alignment of threaded joints shall not be permitted. Engage threads so that not more than three threads remain exposed. [Cover unions with an electrically insulating coating.]

3.1.7 Joint Bonds

Provide joint bonds on metallic pipe to and across buried flexible couplings, mechanical joints, flanged joints [except at places where insulating joints are specified] and joints not welded or threaded to provide electrical continuity. Connect bond wire(s) to the structure(s) by use of exothermic weld kit(s). Clean the structure surface by scraping, filing, or wire brushing to produce a clean, bright surface. [Weld connections using exothermic kits in accordance with the kit manufacturer's instructions.] Check and verify adherence of the bond to the substrate for mechanical integrity by striking the weld with a 908 gram 2 pound hammer. Cover connections with an electrically insulating coating [which is compatible with the existing coating on the structure].

3.1.8 Casings, Insulation, and Seals

Where the pipeline is installed in a casing under a roadway or railway, insulate the pipeline from the casing, and seal the annular space against intrusion of water.

3.1.9 Concrete

Concrete work for cathodic protection requirements shall be 20 Mpa 3000 psi minimum ultimate 28-day compressive strength with 25 mm one inch minimum aggregate conforming to requirements of Section 03300N, "Cast-in-Place Concrete."

3.1.10 Reconditioning of Surfaces

3.1.10.1 Restoration of Sod

Restore unpaved surfaces disturbed during the installation of anodes and wires to their original elevation and condition. Preserve sod and topsoil carefully and replace after the backfilling is completed. Where the surface is disturbed in a newly seeded area, re-seed the area with the same quality and formula of seed as that used in the original seeding.

3.1.10.2 Restoration of Pavement

Repair pavement, sidewalks, curbs, and gutters where existing surfaces are removed or disturbed for construction. Saw cut pavement edges. Graded aggregate base course shall have a maximum aggregate size of 40 millimeters 1 1/2 inches. Prime base course with [liquid asphalt, ASTM D 2028, Grade RC-70] [_____] prior to paving. Match base course thickness to existing but shall not be less than 150 millimeters 6 inches. Asphalt aggregate size shall be 15 mm 1/2 inch [_____], asphalt cement shall [conform to ASTM D 3381, Grade AR-2000] [_____]. Match asphalt concrete thickness to existing but shall not be less than 50 millimeters 2 inches. Repair portland cement concrete pavement, sidewalks, curbs, and gutters using 20.67 MPa 3000 psi concrete conforming to [ASTM C 94] [Section 03300N, "Cast-In-Place Concrete"]. Match existing pavement, sidewalk, curb, and gutter thicknesses.

3.2 FIELD QUALITY CONTROL

Field tests shall be witnessed by the Contracting Officer or his designated representative. Advise the Contracting Officer [5] [_____] days prior to performing each field test. Quality control for the cathodic protection system shall consist of the following:

a. Initial field testing by the Contractor upon construction.

b. Government field testing after initial field test report submission.

c. Warranty period field testing by Contractor.

d. Final field testing by Contractor after one year of service.

3.2.1 Testing

3.2.1.1 Destructive Testing

One completed [prepackaged] anode of each type with lead wires shall be chosen at random for destructive testing and shall be submitted to a static pull test. Anode lead wire connections of anodes shall have sufficient strength to withstand a minimum tensile load of [1335] [_____] N [300] [_____] pounds. Contractor shall perform the tests in the presence of the Contracting Officer.

3.2.1.2 Wire for Power Service

Test wire for power service at 600 volts or less to determine that the wiring system and equipment are free from short circuits and grounds [by a minimum of two megohms]. Perform the test with a megohmmeter having a 500-volt rating.

3.2.1.3 Initial Field Testing of the Cathodic Protection System

The systems shall be tested and inspected by the Contractor's corrosion engineer in the presence of the Contracting Officer's corrosion protection engineer or an approved representative. Record test data, including date, time, and locations of testing and submit report to the Contracting Officer. Contractor shall correct, at his expense, all deficiencies in the materials and installation observed by these tests and inspections. Contractor shall pay for retests made necessary by the corrections.

Testing shall include the following measurements:

a. Base potentials: After [backfilling of the pipe] [installation of structure to be protected] [initial operation of structures containing fluids] [_____] for at least one week, but before connection of anodes to the structure, measure the base (native) structure-to-electrolyte potentials of the [pipe [and the casings]-to-soil] [structure-to-soil]. The locations of these measurements shall be identical to the locations specified for measuring structure-to-electrolyte potentials with anodes connected. Perform measurements at junction boxes, test stations or other locations suitable for test purposes (such as service risers or valves) at intervals not exceeding [15] [30] [122] [_____] meters [50] [100] [400] [_____] feet with readings at each end point and the midpoint as a minimum. For underground storage tanks, take a minimum of three measurements with the reference electrode located as follows:

   (1) Directly over the longitudinal and transverse centerlines of the tank at intervals not exceeding the diameter of the tank and to a distance from the tanks of two times the diameter of the tank.

   (2) At points directly around the circumference of the tank.

b. Reference electrode calibration: Verify calibration of reference electrode by measuring potential difference between permanent copper-copper sulfate reference electrode and an independent reference electrode. Potential difference between the two electrodes shall not exceed 10 millivolts.

c. Insulation testing: Perform insulation testing at each insulating joint or fitting [prior to burying the joint or fitting] before and after the connection of anodes to the pipe at [anode junction box] [test station]. Before connection, test using an insulation checker. After connection, test by measuring the potential shift on both sides of the insulating joint. These tests shall demonstrate that no metallic contact or short circuit exists between the two insulated sections of the pipe. Report and repair defective insulating flanges at the Contractor's expense.

d. Electrical continuity testing: Perform electrical continuity testing for joint bonded pipe prior to backfilling of the pipe. Circulate current through the pipe and compare the measured resistance to the theoretical resistance of the pipe and bond cables. The resistance measured shall not exceed 150 percent of the theoretical resistance.

e. Casing testing: Before final acceptance of the installation, test the electrical insulation of the carrier pipe from casings and correct any short circuits.

f. Anode-to-soil potentials and anode outputs: Measure anode-to-soil potential of each anode with the anode disconnected [through the anode junction box]. After connecting the anodes to the pipe, measure current output of each anode across the shunt installed.

g. Protected potential measurements: With the entire cathodic protection system put into operation for at least [one week] [24 hours], measure structure-to-electrolyte potentials along the

[pipeline [and at all casings]] [structure] using a copper-copper sulfate reference electrode and a voltmeter having an input impedance of not less than 10 megohms. The locations of these measurements shall be identical to the locations used for the base potential measurements.

h. Interference testing: Before final acceptance of the installation, perform interference testing with respect to any crossing and nearby foreign pipelines in cooperation with the owner of the related pipelines. The testing shall verify that the cathodic protection system does not have a deleterious effect on the foreign pipelines, and vice versa. Prepare a full report of the tests, giving all details.

3.2.1.4 Initial Test Report

The Contractor shall submit a field test report of the cathodic protection system. All structure-to-electrolyte measurements, including initial potentials and anode outputs, shall be recorded on applicable forms. Identification of test locations, test station, and anode test stations shall coordinate with the as-built drawings and be provided on system drawings included in the report. The Contractor shall locate, correct, and report to the Contracting Officer any short circuits encountered during the checkout of the installed cathodic protection system.

3.2.1.5 Government Field Testing

The Government corrosion engineer shall review the initial field testing report. Approximately 4 weeks after receipt of the Contractor's initial test report, the system will be tested and inspected in the Contractor's presence by the Government corrosion engineer. The Contractor shall correct, at his expense, differences in the materials and installation observed by these tests and inspections. The Contractor shall pay for all retesting done by the Government corrosion engineer made necessary by the correction of deficiencies.

3.2.1.6 One Year Warranty Period Testing

The Contractor shall inspect, test, and adjust the cathodic protection system [quarterly] [semi-annually] [_____] for one year, [two] [one] interim inspections total, to ensure its continued conformance with the inspections outlined above. The performance period for these tests shall commence upon preliminary acceptance for the cathodic protection system by the Contracting Officer. Copies of the test report, including field data, certified by the Contractor's corrosion engineer, shall be forwarded to the Contracting Officer and the Government corrosion engineer.

3.2.1.7 Final Field Testing

Conduct final field testing of the cathodic protection system utilizing the same procedures indicated in the initial field testing of the cathodic protection systems. The Contractor shall inspect, test, and adjust the cathodic protection system after one year of operation to ensure its continued conformance with the inspections outlined above. The performance period for these tests shall commence upon preliminary acceptance for the cathodic protection system by the Contracting Officer. Copies of final testing report, certified by the Contractor's corrosion engineer, shall be submitted to the Contracting Officer and the Government corrosion engineer for approval.

3.2.2 Criteria for Cathodic Protectionof Steel Structures

Conduct in accordance with [NACE RP0169] [NACE RP0285]. Criteria for determining the adequacy of protection shall be selected by the corrosion engineer as applicable:

a. A negative voltage of at least 0.85 volt as measured between the structure surface and a saturated copper-copper sulfate reference electrode contacting the earth [electrolyte]. Determination of this voltage is to be made with the protective current applied to the [structure] [tank] [pipeline] for a minimum of [24] [_____] hours. Voltage drops must be considered for valid interpretation of this voltage measurement. The method of voltage drop consideration shall be identified by the Contractor's corrosion engineer and approved by the Government corrosion engineer.

b. A minimum polarization voltage shift of 100 mV measured between the structure surface and a saturated copper-copper sulfate reference electrode contacting the [earth] [electrolyte]. This voltage shift shall be determined by interrupting the protective current and measuring the polarization decay. At the instant the protective current is interrupted ("instant off"), an immediate voltage shift will occur. The voltage reading just after the immediate shift shall be used as the base reading from which to measure the polarization decay. The polarization decay shall be the difference between the base reading and a voltage measurement made [24] [48] [_____] hours after the disruption of protective current.

3.3 OPERATION AND MAINTENANCE MANUAL PREPARATION

THE Contractor shall include the approved initial testing report with the operation and maintenance data provided for the cathodic protection system in accordance with Section 01781N, "Operation and Maintenance Data."

3.4 DEMONSTRATION

3.4.1 Instructing Government Personnel

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NOTE: There are restrictions on the type and extent of training. Training is usually on-site, 2 days or less. Factory representatives or others provide basic instructions to facility maintenance and operation personnel. If more extensive training is required, e.g., student travel, special consultants, etc., consult the Contract Division Director and the head of the Comptroller Department for assistance.

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During the warranty testing and at a time designated by the Contracting Officer, make available the services of a technician regularly employed or authorized by the manufacturer of the cathodic protection system for instructing Government personnel in the proper operation, maintenance, safety, and emergency procedures of the cathodic protection system. The period of instruction shall be not less than [one] [_____] but not more than [two] [_____] 8-hour working day[s]. Conduct the training at the jobsite or at another location mutually satisfactory to the Government and

the Contractor. The field instructions shall cover all of the items contained in the operation and maintenance manual.

3.5 SCHEDULE

Some metric measurements in this section is based on a mathematical conversion of an English unit measurement, and not on metric measurement commonly agreed upon by the manufacturers or other parties. The English and metric units for the measurements shown are as follows:

Products	English Units	Metric Units
a. Reference Electrodes		
- Diameter	1 1/4 inches	32 mm
- Length	10 inches	255 mm
b. Warning Tape		
- width	3 inches	75 mm

-- End of Section --